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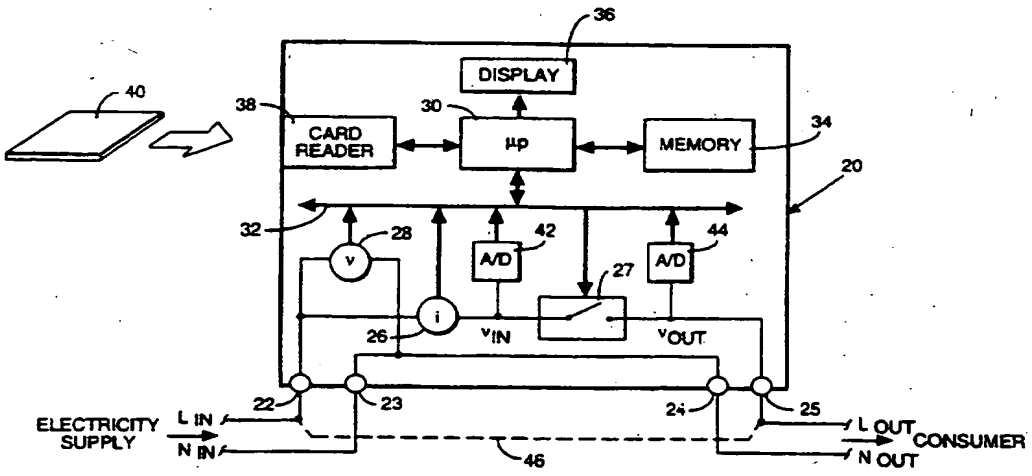
(54) Isolation bypass detector for a commodity supply line

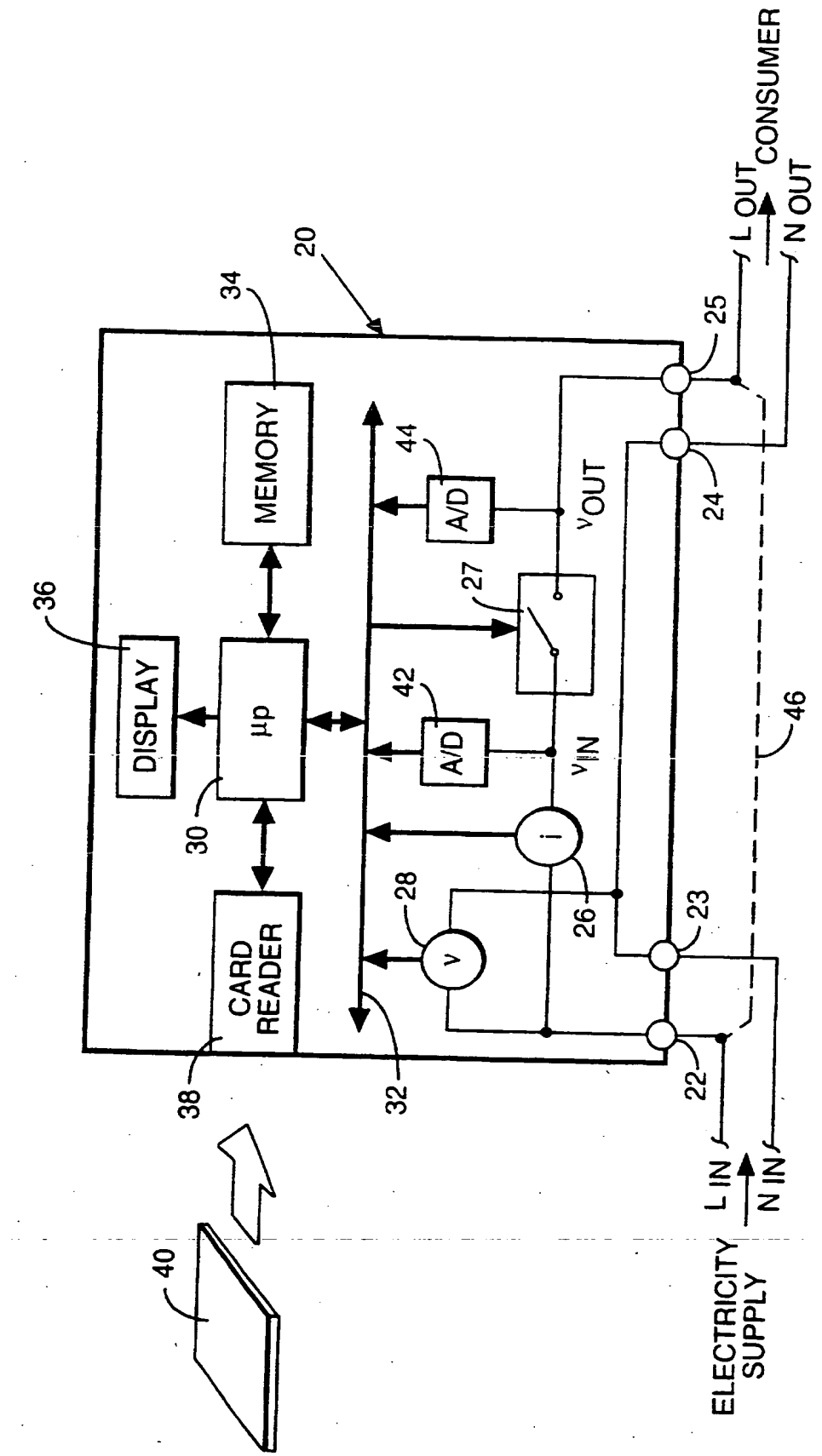
(57) An arrangement measures the pressure or potential difference (Vin - Vout) across isolating means 27 located within a commodity (e.g. electricity, water or gas) supply line L. The arrangement detects if the pressure or potential difference (Vin - Vout) is below a preset value when the isolating means 27 is in operation. The isolating means 27 may be a contactor when the commodity is electricity or a valve when the commodity is water or gas. The arrangement may be used with a prepayment meter to detect and indicate possible fraudulent bypassing of the meter. With regard to an electrical supply, the arrangement may further include means to determine if the phase difference between the input and output voltage signals (Vin, Vout) has dropped below a preset value.

Fig.1.



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Fig.1.



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PREPAYMENT COMMODITY METERS

This invention relates to prepayment commodity meters and is especially concerned with an apparatus for, and method of, detecting when such a meter has been bypassed.

A prepayment commodity meter is a meter which measures consumption of a commodity, for example electricity, water or gas, which a consumer has paid for in advance and prevents supply of the commodity when the consumer's credit becomes exhausted or is absent. The credit can be in a number of different forms, for example, it can be in the form of cash or tokens which are deposited by the consumer in the meter or an electronic or magnetic card which is inserted in the meter and which carries information indicating how many units of the commodity have been paid for in advance.

Such meters have become progressively more complex in their operation, thereby preventing many forms of possible fraud. For example, some prepayment electricity meters include circuitry to detect for reverse operation of the meter in which separate registers accumulate the number of units of electricity consumed for forward and reverse flow. It is also known for prepayment electricity meters to record the date and time whenever the electricity supply is interrupted. The electricity supplier then compares this record with the number of power failures known to have occurred. A discrepancy in these two readings indicate that a site visit may be necessary to check for tampering or a genuine fault.

It has been estimated that in certain geographic areas within the United Kingdom up to

20% of the electricity supply is lost due to meter fraud. With prepayment electricity meters it has been found that some consumers have been connecting an electrical bypass across the meter in order to obtain electricity without paying for it. If it is suspected that bypassing of the meter is taking place, a site visit must be made to prove that the meter has been bypassed so that action can be taken against the offender. Past experience all too often shows that before a meter inspection is made the offender has removed the bypass and credited the meter with a nominal amount of credit, or invoked a facility for emergency credit, such that the meter has resumed normal operation. This makes the detection, but equally importantly the proof, of meter bypassing difficult in practice.

One known method for detecting if a prepayment electricity meter has been bypassed is to detect for an electrical current returning through the neutral terminals of the electricity meter. When a consumer's credit is exhausted the meter prevents supply of electricity by breaking the electrical path between the input and output live terminals of the meter by means of a contactor. If an electrical link is connected across the live terminals of the meter thereby bypassing the meter, electricity can be extracted when no credit remains. By doing so, however, this results in an electrical current flowing in the neutral line which is detected by a current sensor indicating that the meter has been bypassed.

A disadvantage with this method of detection is that it is defeated if the neutral terminals are also bypassed. Fortunately it is not common general knowledge and has thus not known to have been widely used. This solution is also costly as it requires a current sensor which is capable of operating at mains voltages. A need exists, therefore, for a reliable and inexpensive method of detecting when a prepayment meter is bypassed.

According to the invention apparatus for use with a Prepayment commodity meter of a type which includes isolating means which prevents supply of the commodity when consumer credit is absent comprises: means for measuring a pressure difference across the isolating means when the isolating means is operative and means for determining whether said difference is below a predetermined value indicating the isolating means is bypassed.

It is known to convert a commodity comsumption registering meter of a type which logs commodity consumption but does not include isolating means to a prepayment commodity meter by the addition of what are refered to as "charge collectors". A charge collector essentially compises means for logging consumer credit and isolating means which prevent supply of the commodity when consumer credit is exhausted or absent.

According to another aspect of the invention apparatus for use with a commodity consumption registering meter comprises: isolating means which prevent supply of the commodity when consumer credit is absent; means for measuring a pressure difference across the isolating means when the isolating means is operative and means for determining whether said difference is below a predetermined value indicating the isolating means is bypassed.

In one particular application the commodity consumption registering meter, or prepayment commodity meter, is an electricity meter and the pressure difference is an electrical potential difference. The isolating means conveniently comprises a contactor. In such an application the electrical potential difference is the difference between the

voltages appearing on respective sides of the isolating means and the voltages are cyclically alternating, in which case the apparatus preferably further comprises: means for measuring a difference in phase between the respective voltages and means for determining whether said difference in phase is below a preselected value. By measuring the difference in phase as well as the potential difference reduces the likelihood of the apparatus being falsely triggered into believing the contactor has bean bypassed by noise pick up which will have a different phase.

In a further application the commodity consumption registering meter, or prepayment commodity meter, is a gas or water meter and the pressure difference is the gas or water pressure respectively across the isolating means. In such an arrangement the isolating means comprises a value.

According to a further aspect of the invention there is provided a method for use with a commodity meter of a type which includes isolating means which prevents supply of the commodity when a consumer credit is absent, the method being for detecting if the isolating means has been bypassed and comprising the steps of: when the isolating means is operative, measuring a pressure difference across the isolating means; and determining whether said difference is below a predetermined value, indicating that the isolating means is bypassed.

An embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawing which is a schematic representation of a prepayment electricity meter including apparatus in accordance with the invention.

Referring to the drawing, a prepayment electricity meter 20 comprises a pair of input terminals 22, 23 for connecting the prepayment meter 20 to the live L_{in} and neutral N_{in} lines of the electricity supply. A corresponding pair of output terminals 24, 25 is provided for connection to the live L_{out} and neutral N_{out} lines of a consumer's premises. The neutral input 23 and output 24 terminals are electrically connected together inside the meter 20, though it will be appreciated that this is not essential for the operation of the invention.

A current sensor 26 and contactor switch 27 are connected in series between the live input 22 and live output 25 terminals. The current sensor 26 measures the electrical current, i, flowing between the terminals 22, 25 and produces a digital value representative of the instantaneous electrical current. A voltage sensor 28 connected across the input terminals 22, 23 measures the voltage, v, between the terminals and produces a digital value representative of the instantaneous voltage. These digital values, current i and voltage v, are read by a microprocessor 30 by means of a data bus 32. The microprocessor 30 is configured to calculate the electrical energy consumed from these instantaneous values using a known method. A record of the number of units of energy of electricity consumed is stored in a memory 34 connected to the microprocessor 30. A display 36 is provided for displaying information to the consumer such as the total number of units of electricity used and the number of units of credit remaining.

A card reader 38 connected to the microprocessor 30 is provided to communicate with a card 40 which is arranged to engage in a slot (not shown) in the card reader 38.

In operation, the consumer pays for a specified number of units of electricity at a local office, which information is transferred to the card 40. The consumer places the card 40 in the slot of the card reader 38, which transfers the number of units of electricity to the microprocessor 30 which updates the display and the memory 34 with this information. As the consumer uses electricity, this is detected by the sensors 26, 28 and the microprocessor 30 deducts the number of units consumed from the number of units of credit stored in memory 34. The number of units of electricity remaining is displayed on the display 36. The microprocessor 30 is configured to allow continued supply of electricity whilst the memory 34 indicates that the consumer is in credit.

Once the consumer's credit is exhausted, the microprocessor 30 instructs the contactor 27 to "open" by means of the data bus 32 thereby preventing further supply of electricity from the meter 20. The meter 20 may include an emergency credit facility (not shown) which when invoked by the consumer credits the meter with a limited number of units. Such a facility ensures continued supply of electricity should a consumer's credit become exhausted at a time when it is impracticable to purchase further units of electricity.

Two analogue-to-digital (A-to-D) converters 42, 44 connected on either side of the contactor 27 provide a digital value representative of the instantaneous voltage, v_{in} and v_{out} respectively, appearing on either side of the contactor 27. The digital outputs of the A-to-D converters 42, 44 are connected to the data bus 32.

When the contactor 27 is "open" such that the live output terminal 25 is isolated, the

microprocessor 30 reads the two A-to-D converters to determine the instantaneous voltages v_{in} and v_{out} relative to neutral or some other convenient reference potential for example earth . With the contactor 27 "open", the output side L_{out} of the contactor 27 is isolated from the electricity supply and accordingly the voltage v_{out} will be expected to be zero volts. In contrast the voltage appearing on the input side v_{in} of the contactor 27 will be the normal mains supply voltage which in the case of domestic electricity supply in the UK in a nominal rms value of 240 volts. The microprocessor 30 calculates the voltage difference (v_{in} - v_{out}) and compares this with a predetermined value to establish if the meter 20 has been bypassed. Since the voltage difference (v_{in} - v_{out}) is greater than the predetermined value indicates that the meter 20 has not been bypassed.

Consider now the case when the meter 20 is bypassed by a link 46 connected between the input and output terminals 22 and 25. In this condition, the voltage v_{out} will equal v_{in} and the microprocessor 30 will detect the presence of the bypass 46 since the voltage difference (v_{in} - v_{out}) across the contactor 27 is now less than the predetermined value.

Since the live output terminal 25 is isolated when the contactor 27 is operative the voltage v_{out} can float which can result in it having a value close to the normal mains supply voltage. To prevent false triggering of the system the predetermined voltage difference is selected to be small typically less than twenty volts for a mains supply operating at a nominal 240 volt rms.

Upon detecting that the meter 20 has been bypassed, the microprocessor 30 records the time and date on which the meter was bypassed in the memory 34. The next time the

consumer places the card 40 in the card reader 38, the microprocessor 30 copies the time and date upon which it detected that the meter 20 had been bypassed onto the card 40. This information is communicated back to the commodity supplier when the consumer next recredits the card 40. The microprocessor 30 does not delete this information from its memory 34 until the commodity supplier has acknowledged receipt of the information which he does by writing an acknowledgement message onto the card 40. In this way a customer who looses their card 40 will not prevent the information reaching the supplier, but merely delay it. Until an acknowledgement of the information is received the microprocessor 30 is configured to write the information to any valid card 40 that is inserted into the card reader 38.

The meter 20 can also be interrogated by an engineer when a site visit is made by placing an appropriate card in the card reader 38. The microprocessor 30 is configured to display a number of set messages that can only be read when an engineer's card is placed in the card reader 38. These messages identify any instances of tamper and are only accessible by depressing a button which is protected by a security seal.

The voltages v_{in} and v_{out} represent instantaneous voltages since the mains voltage is an alternating supply. These instantaneous values v_{in} and v_{out} are converted into peak values, by the microprocessor 30 by reading these instantaneous voltage values at a number of intervals and the recording the largest values. Since the voltages v_{in} and v_{out} will be in phase and the measurements of v_{in} and v_{out} are carried out substantially simultaneously, the measurements of the voltages will occur at the same point in the mains signal cycle. As a result it is not critical to determine an exact peak value. It is

important, however, to ensure that the voltage difference (v_{in} - v_{out}) is determined away from a zero crossing in the mains cycle to prevent false triggering of the system. It will be appreciated however that or other form of the voltage can be used, for example root mean square (rms) value.

In an alternative embodiment the microprocessor 30 is configured to calculate not only the magnitude of the voltages v_{in} and v_{out} when testing for the presence of a bypass but also the phase relationship of v_{in} to v_{out}. By ensuring the phase of the voltages are the same to within a predetermined tolerance gives further confidence in checking for the presence of a bypass and prevents false triggering of the system as a result of electrical noise pick up which may have a different phase relationship to v_{in}.

It will be appreciated that the method described does not suffer the disadvantages of those of the prior art. For example the method of the invention is not affected if the neutral terminals 23 and 24 are also bypassed. Furthermore even if the live mains supply L_{in} were to be disconnected from the live input terminal 22 and reconnected to the live outlet terminal 25 the processor 30 would detect a bypass since v_{out} will exceed v_{in} rather than v_{in} exceeding v_{out}. Even if the meter 20 were to be completely disconnected from the mains supply the apparatus would still detect this form of tamper, since the voltages v_{in} and v_{out} would then fall to zero volts such that the potential difference across the contactor 27 still remained below the predetermined value.

As the apparatus of the present invention is only intended to detect a bypass whilst the contactor 27 is "open", the microprocessor 30 is configured only to read and compare

the voltages v_{in} v_{out} when it has instructed the contactor 27 to "open". The increased overhead in microprocessor 30 time as a result of the invention is therefore minimal. Furthermore the reading and comparison of the voltages v_{in} and v_{out} is not a time-critical operation since often when a meter is bypassed it will be in such a condition for hours, days or possibly months.

Whilst in the embodiment described a separate A - to- D converter 42 is provided to determine the voltage v_{in} in an alternative arrangement the voltage sensor 28 is used to measure v_{in}.

It will be appreciated that whilst the present invention has been described in relation to a prepayment electricity meter, the present invention also applies to other forms of prepayment meter. For example, bypassing of a prepayment water meter or gas meter can be detected by measuring the pressure difference across the isolating valve and comparing this with a predetermined value. Furthermore the invention can be applied to meters which accept other form of credit such as tokens or cash.

It is also envisaged that the meter could communicate to the supplier that it had been bypassed by means other than the card. For example the meter can be interrogated using a hand held unit which reads the meter readings and any events stored through an optical communication part. Alternatively the meter can be remotely interrogated using mains borne signalling which communicates with the meter via signals over the mains supply lines or using a radio reading system or other form of remote reading equipment.

In the specific embodiment described the prepayment meter 20 is a single unit which both logs electricity consumption, logs consumer credit and prevents further supply of electricity when consumer credit is exhausted. It is also known to convert existing electricity meters, which merely log electricity consumption, to a prepayment meter by the addition of a separate "charge collector". It will be appreciated that the present invention applies equally to such an arrangement irrespective of whether the contactor is an integral part of the meter or not.

CLAIMS

1. Apparatus for use with a commodity consumption registering meter the apparatus comprising:

isolating means which prevents supply of the commodity when consumer credit is absent;

means for measuring a pressure difference across the isolating means when the isolating means is operative and

means for determining whether said difference is below a predetermined value indicating the isolating means is bypassed.

2. Apparatus for use with a prepayment commodity meter of a type which includes isolating means which prevents supply of the commodity when consumer credit is absent, the apparatus comprising:

means for measuring a pressure difference across the isolating means when the isolating means is operative and

means for determining whether said difference is below a predetermined value indicating the isolating means has been bypassed.

3. Apparatus, according to Claim 1 or Claim 2, in which the commodity consumption meter or prepayment commodity meter is an electricity meter and the pressure difference is an electrical potential difference.

4. Apparatus, according to Claim 3, wherein the electrical potential difference is the difference between the voltages appearing on respective sides of the isolating means and the voltages are cyclically alternating, the apparatus further comprising: means for measuring a difference in phase between the respective voltages and means for determining whether said difference in phase is below a preselected value.

5. Apparatus, according to Claim 3 or Claim 4, in which the isolating means is a contactor.

6. Apparatus, according to Claim 1 or Claim 2, in which the commodity consumption meter or prepayment commodity meter is a water or gas meter.

7. Apparatus, according to Claim 6, in which the isolating means is a valve.

8. Apparatus, according to Claim 1, substantially as described by way of reference to the accompanying drawing.

9. A method for use with a commodity meter of a type which includes isolating means which prevents supply of the commodity when a consumer credit is absent, the method being for detecting if the isolating means has been bypassed and comprising the steps of:

when the isolating means is operative, measuring a pressure difference across the isolating means; and

determining whether said difference is below a predetermined value, indicating

that the isolating means is bypassed.

10. A method according to Claim 9 and wherein the pressure difference is an electrical potential difference.

11. A method, according to Claim 10, wherein the electrical potential difference is the difference between the voltages appearing on respective sides of the isolating means and the voltages are cyclically alternating, the method further comprising the steps of:

measuring a difference in phase between the respective voltages and

determining whether said difference in phase is below a preselected value.

12. A method, according to Claim 9, wherein the pressure difference is that of a fluid.

The Patent Office

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Application No:	GB 9610146.4	**Examiner:**	John Watt
Claims searched:	1 - 12	**Date of search:**	1 August 1996

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): G1U (UR1124, UR21133); G4V (VMK)

Int Cl (Ed.6): G01D 4/00, 4/02; G01R 11/24; 21/133; G03B 13/00, 13/02, 21/00

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	GB 2281401 A (AMPY) see whole document	X: 1-3, 5, 9 &10

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.